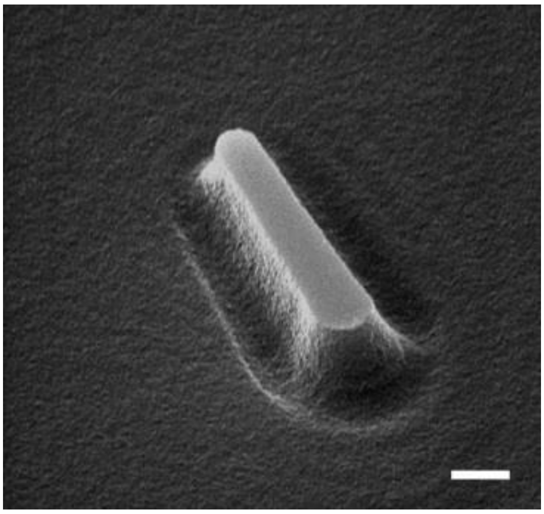
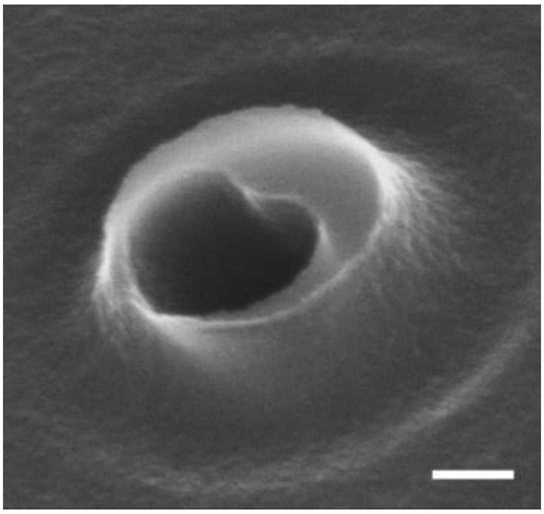
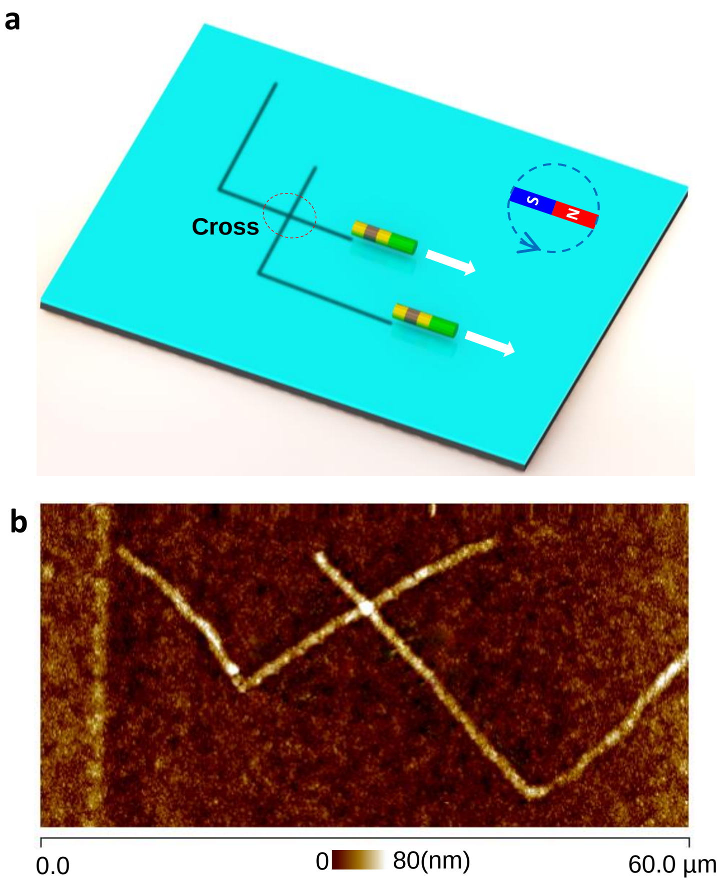
Supplementary Figures



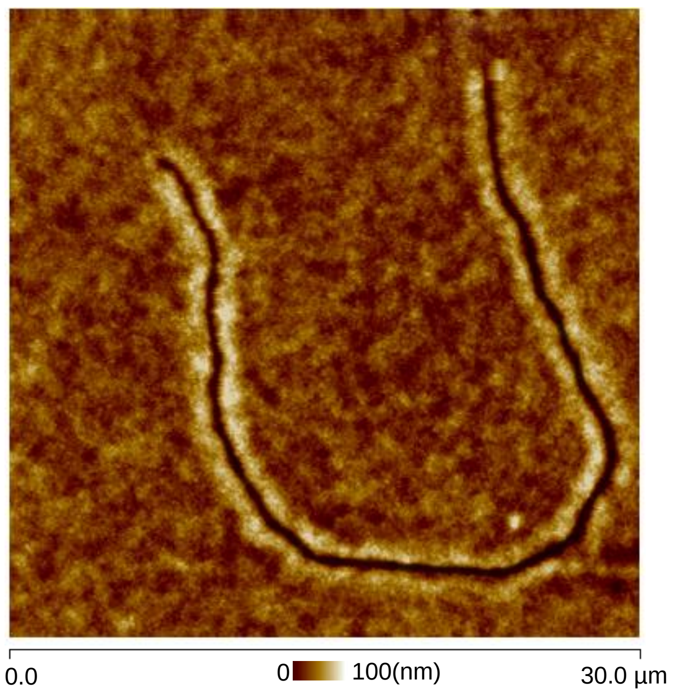
Supplementary Figure 1: Mask effect of the nanowire motors. A SEM image of a short nano ridge obtained by using a static 200 nm-diameter nanowire as a stationary mask. Scale bar, 200 nm



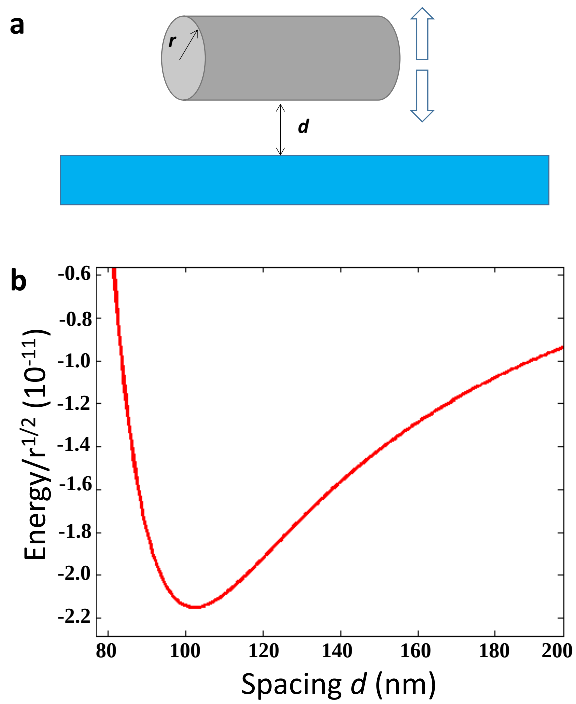
Supplementary Figure 2: Near-field light focusing of Janus spherical motors. A SEM image of a nano hole obtained by using a static 2.16-μm Janus sphere as a near-field lens. The asymmetric shape of the nano hole resulted from the asymmetric optical properties of the Janus sphere. Scale bar, 500 nm.



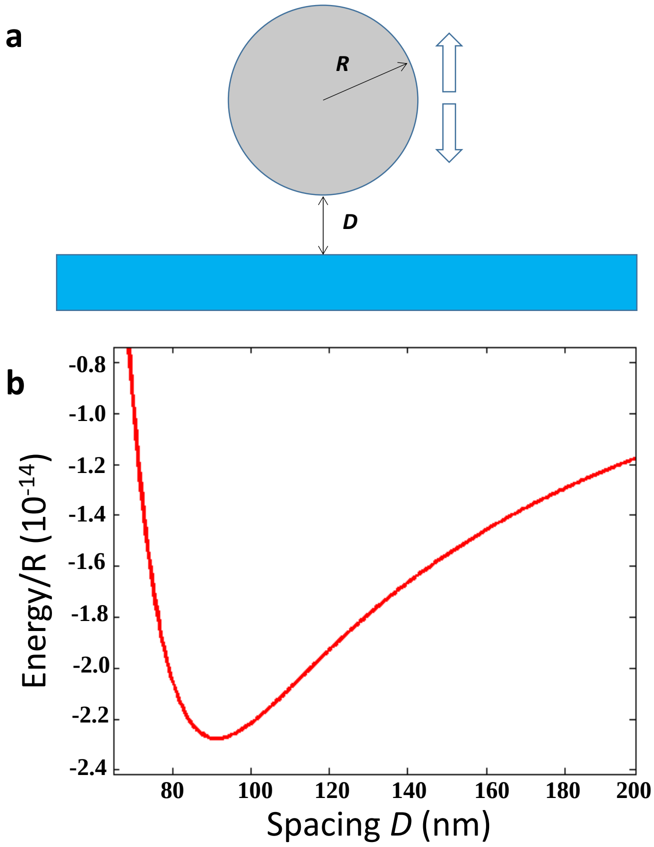
Supplementary Figure 3: Crossing feature patterned by nanowire motors. a) Schematic illustration of the moving trajectories of the two magnetically-guided nanowire motors used for patterning crossing features. b) A corresponding AFM image of the crossing feature patterned by these nanowire motors.



Supplementary Figure 4: Patterned feature by a Janus sphere motor. A trench line pattern created by a 2.16-µm Janus sphere motor.



Supplementary Figure 5: Schematic of nanowire-surface spacing and interaction energy. a) Self-positioning of a nanowire motor. b) Total interaction energy (van der Waals attraction plus electrostatic repulsion) between a nanowire and the photoresist surface.



Supplementary Figure 6: Schematic of Janus sphere motor-surface spacing and interaction energy. a) Self-positioning of Janus sphere motor. b) Total interaction energy (van der Waals attraction plus electrostatic repulsion) between a microsphere and the photoresist surface.

Supplementary Notes

Supplementary Note 1: Discussion of nanomotor-surface spacing: nanowire motors.

In the first case of nanowire motors, the balance between these forces controls the spacing *d*. For the sake of simplicity, we assume the nanowire motor as a cylindrical structure here, as displayed in Supplementary Figure 5a. The van der Waals interaction energy $E_{v(c)}$, between a cylindrical structure and a surface, is given by[1]:

$$E_{v(c)} = -\frac{A\sqrt{r}}{12\sqrt{3}^{3/2}} \tag{1}$$

Where A is the Hamaker constant, r is the radius of the nanowire motor and d is the nanomotor-surface spacing.

The electrostatic double-layer interaction energy between a cylindrical structure and the surface is described by[1]:

$$E_{e(c)} = 64\pi\varepsilon\varepsilon_0(\frac{kT}{q})^2 \tan(\frac{q\varphi_1}{4kT}) \tanh(\frac{q\varphi_2}{4kT})k^{1/2} (\frac{R}{2\pi})^{1/2}e^{-kd} \tag{2}$$

Where ε is the dielectric constant of water, ε_0 is the free-space permittivity, k^{-1} is the Debye length, k is the Boltzmann constant, T is the thermodynamic temperature, q is the elementary charge, $\varphi_1$and φ_2 are the surface potential for the nanomotor and the photoresist surface, respectively.

The total interaction energy (van der Waals attraction plus electrostatic repulsion) between the nanowire and the surface can be written as

$$E_{(c)} = E_{v(c)} + E_{e(c)} \tag{3}$$

The mean surface spacing can be determined by finding the minimal total interaction energy. While the specific values of A, k^{-1}, φ_1 and φ_2 were not measured for our systems, we can estimate the approximate nanomotor-surface spacings by using the reasonable tested or calculated parameters. Here we use $A = 0.87 \times 10^{-20}$J and φ_1=40 mV by assuming the metallic nanowire as a colloidal metallic nanoparticle[2,3]. We also use the Debye length k^{-1}= 10 nm for the hydrogen peroxide solution and φ_2=50 mV for a smooth surface[4]. Supplementary Figure 5b displays the dependence of the total interaction energy of the nanowire upon the surface spacing. Our estimated results show the balanced nanowire-surface spacing to be 105 nm.

Supplementary Note 2: Discussion of nanomotor-surface spacing: Janus sphere motors.

In the second case of Janus sphere motors, the balance between van der Waals force and the repulsive electrostatic double-layer force controls the spacing *D*. To simplify the discussion, we assume here the Janus sphere motor as a microsphere, as displayed in Supplementary Figure 6a. The van der Waals force between a sphere particle and a surface is well-known as [1]:

$$E_{v(s)} = -\frac{AR}{6D} \tag{4}$$

Where *R* is the radius of the microsphere and *D* is the sphere-surface spacing.

The electrostatic double-layer interaction forces between the microsphere and the surface can be written as[1]:

$$E_{e(s)} = 64\pi\varepsilon\varepsilon_0(\frac{kT}{q})^2 \tan(\frac{q\varphi_1}{4kT}) \tanh(\frac{q\varphi_2}{4kT}) R\, e^{-kD} \tag{5}$$

Total interaction energy (van der Waals attraction plus electrostatic repulsion) between the nanowire and the surface can be written as

$$E_{(s)} = E_{v(s)} + E_{e(s)} \tag{6}$$

Similar to the cylindrical wires, the mean surface spacing can be determined by calculating the minimal total interaction energy $E_{(s)}$. Here we use $A = 1.23 \times 10^{-20}$J, Debye length k^{-1} = 10 nm, and φ_1 =φ_2=50 mV for the colloidal sphere-smooth surface system[4]. Supplementary Figure 6b displays the dependence of the total interaction energy of the microsphere upon the surface spacing. Our estimated results show the balanced sphere-surface spacing to be 90 nm.

Supplementary References:

1. Israelachvili, J. N. Intermolecular and surface forces, 3rd Edition, Academic Press, Burlington, MA, (2011).
2. Enustun, D. B. V. & Turkevich, J. Stability of Colloidal Gold and Determination of the Hamaker Constant, *J. Phys. Chem.* **82**, 2710-2711 (1978).
3. Dougherty, G. M. *et al*. The zeta potential of surface-functionalized metallic nanorod particles in aqueous solution. *Electrophoresis* **29**, 1131–1139 (2008).
4. Suresh, L. & Walz, J. Y. Effect of surface roughness on the interaction energy between a colloidal sphere and a flat plate. *J. Colloid Interface Sci.* **183**, 199–213 (1996).